

# Estimating the Impact of Climate Change on Electricity Load for California's Utilities

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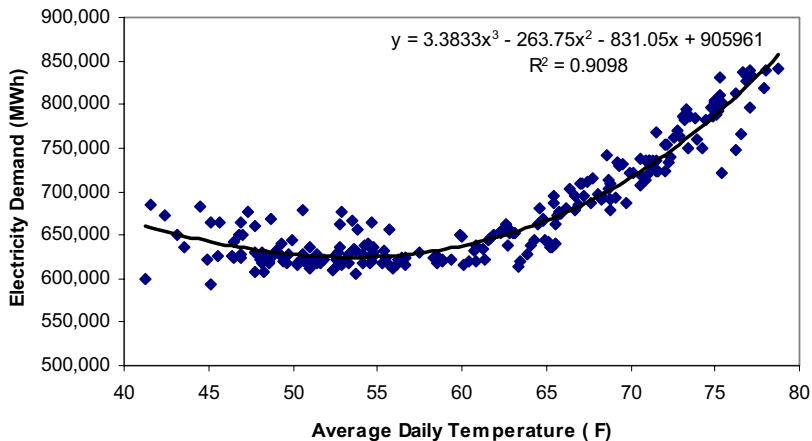
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PRELIMINARY AND NOT FOR ATTRIBUTION

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# Temperature and Electricity Demand (CalISO)



Source: Franco and Sanstad (2006)

# Utility Specific Share of Residential Sales (2001)

Anaheim Public Utilities Dept.



Burbank Public Service Dept.



Glendale Public Service Dept.



Imperial Irrigation District



LAWP



Modesto Irrigation District



Pacific Gas &amp; Electric Co.



Pasadena Water &amp; Power Dept.



Riverside Utilities Dept.



SACMUD



San Diego Gas &amp; Electric Co.



Silicon Valley Power



Southern California Edison Co.



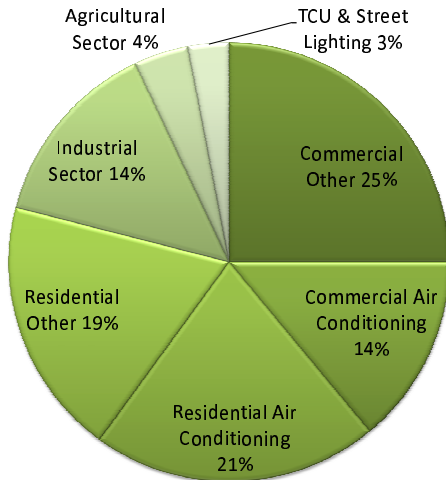
Turlock Irrigation District



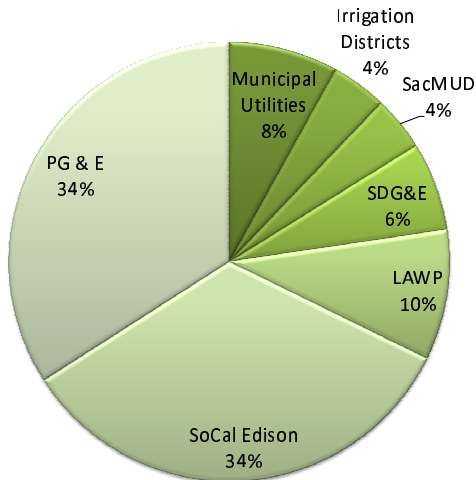
Vernon Light &amp; Power Dept.



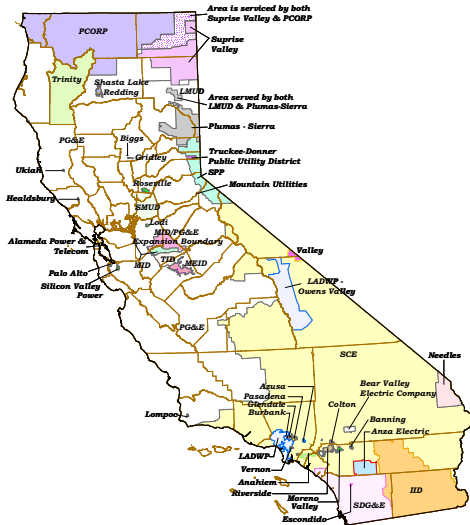
# Sectoral Peak Demand by Use (2005)



# Utility Size by Retail (2001)



# Map of Utilities with Retail Sales (2007)



# Research Question

- What is the utility specific projected impact of Climate Change on
  - ① Total Electricity Consumption (Demand)
  - ② Frequency of “near peak days”
  - ③ Peak Demand

# Literature

- Baxter and Calandri (1992)
- Crowley and Jones (2003)
- Mendelsohn (2006)
- Mansur, Mendelsohn and Morrison (2005)
- Franco and Sanstad (2006)
- Miller, Hayhoe, Jin and Auffhammer (2006)
- Deschenes and Greenstone (2007)



# Data

## Electricity Data:

- Hourly Load
- FERC form 714
- Utilities with annual peak demand greater than 200 megawatts results in 15 usable utilities.

## Weather Data:

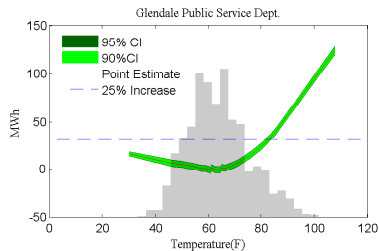
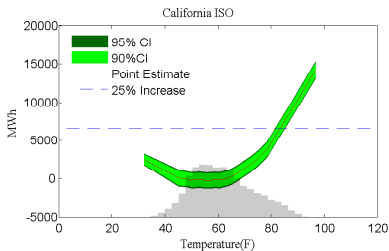
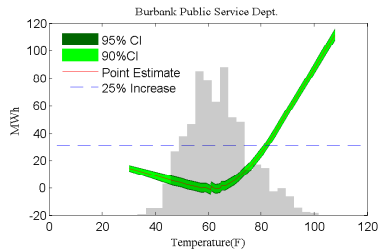
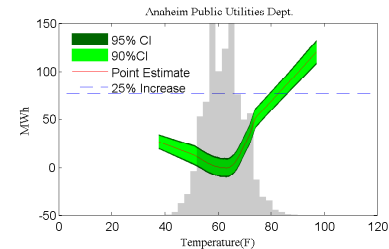
- NCDC Hourly Temperature
- NCDC Hourly Rainfall
- Averaged across stations in utility service area

# Specification

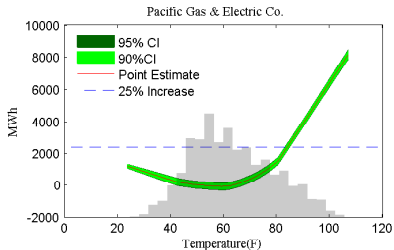
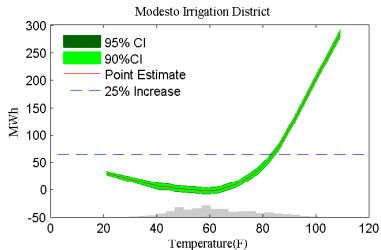
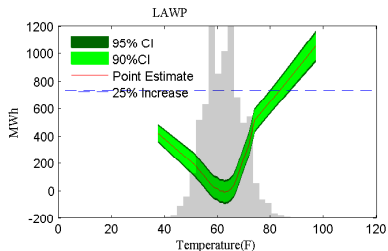
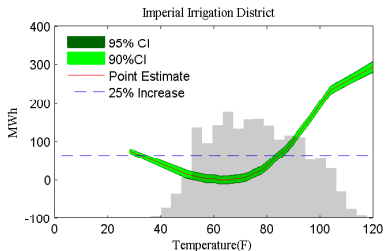
$$Load_t = f(Temp_t) + g(Precip_t) + \sum_{i=1}^{56} \omega_i + \sum_{j=1}^5 \delta_j + \sum_{s=1}^{24} \zeta_s + \sum_{y=1}^{12} \psi_y + \eta_t$$

$Load_t$	Hourly Load in MW
$Temp_t$	Mean Hourly Temperature in Degree Fahrenheit
$Precip_t$	Mean Daily Rainfall in <i>mm</i>
$\omega_i$	Week of the year fixed effects
$\delta_j$	Day of the week fixed effect
$\zeta_s$	Hour of the day fixed effects
$\psi_y$	Year fixed effects
$\eta_t$	Nicely behaved error term

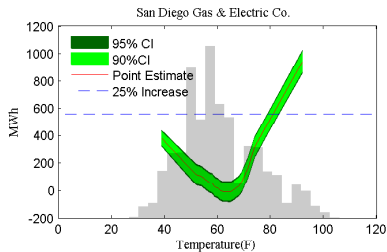
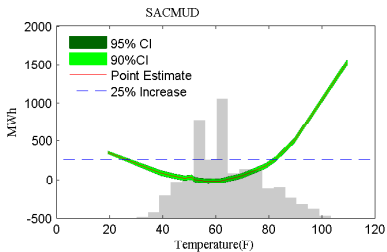
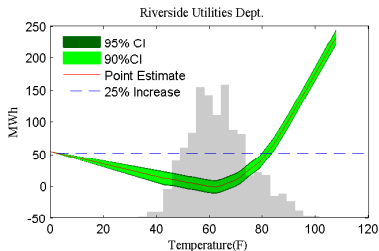
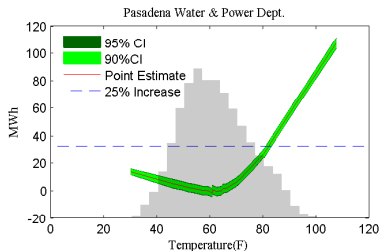
# Estimation Results (1/4)



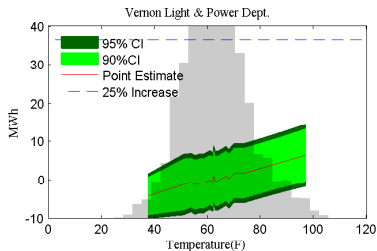
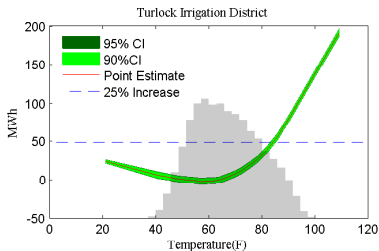
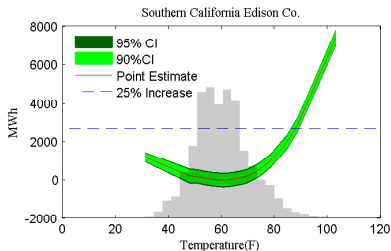
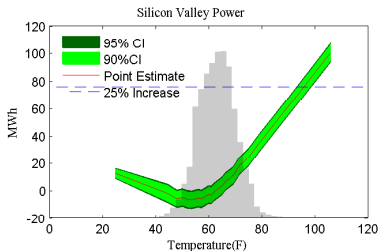
# Estimation Results (2/4)



# Estimation Results (3/4)



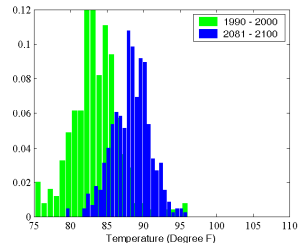
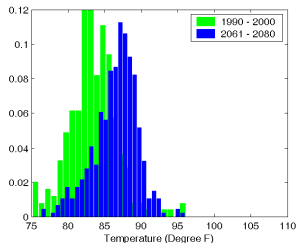
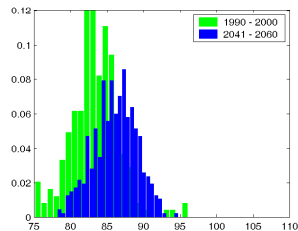
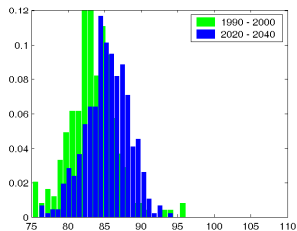
# Estimation Results (4/4)



# Climate Model for Simulation

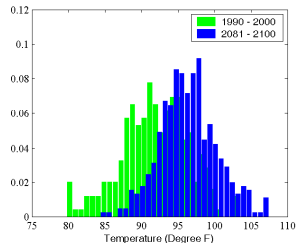
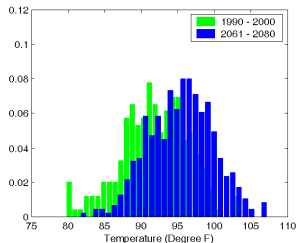
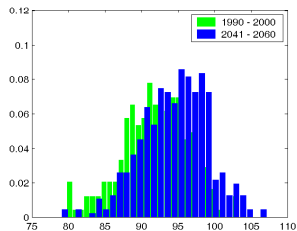
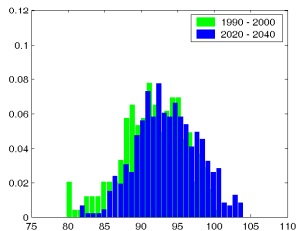
- National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM)
- Provides predictions at for 3-hour intervals
- Force model by SRES A1f1 Scenario
- Low sensitivity model
- Hadley 3 Predicts annual average increase of 5.8 Degree Celsius.
- NCAR PCM predicts annual average increase of 3.8 Degree Celsius

# Distribution of July Temperatures 4-7pm (SVP)

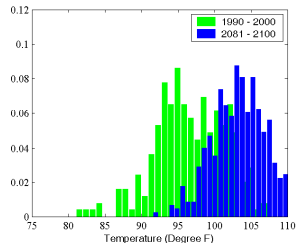
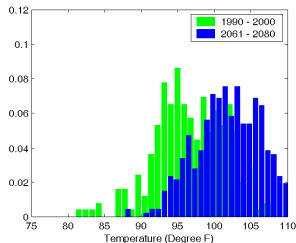
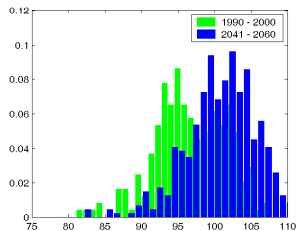
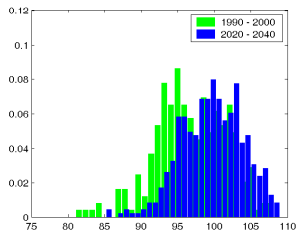




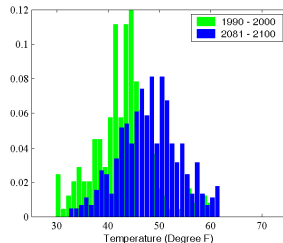
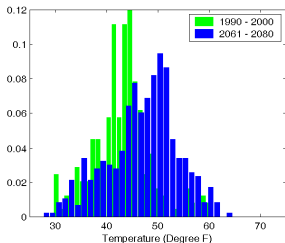
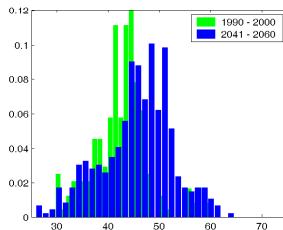
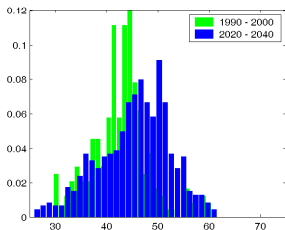
# Distribution of July Temperatures 4-7pm (SDGE)



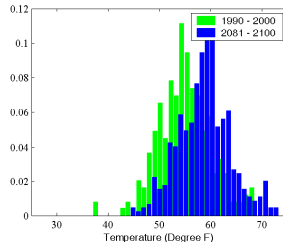
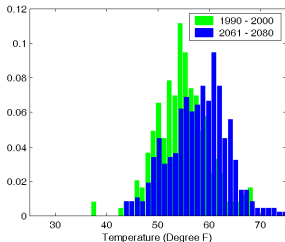
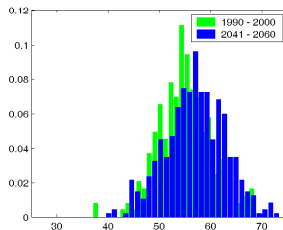
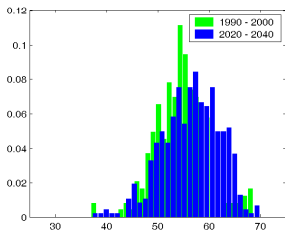
# Distribution of July Temperatures 4-7pm (IID)



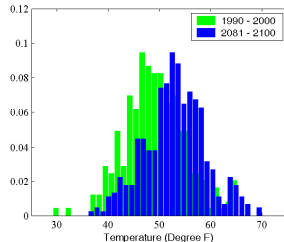
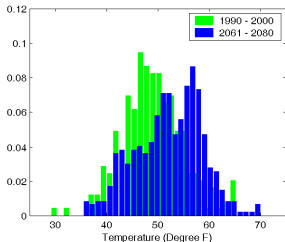
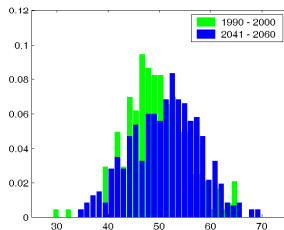
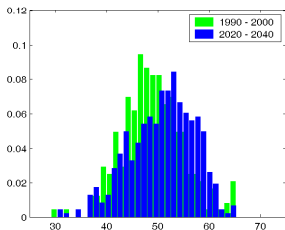
# Distribution of January Temperatures 4-7pm (SVP)



# Distribution of January Temperatures 4-7pm (SDGE)



# Distribution of January Temperatures 4-7pm (IID)



# Simulated Increases in Annual Consumption (A1f1)

Utility	2020-40	2041-60	2061-80	2081-2100
Vernon Light & Power Dept.	1.08%	1.22%	1.35%	1.79%
Silicon Valley Power	2.15%	2.36%	2.57%	3.37%
Sacramento Municipal Utility District	2.04%	2.50%	2.79%	4.11%
Glendale Public Service Dept.	2.36%	2.95%	3.28%	4.58%
Pacific Gas & Electric Co.	2.54%	3.03%	3.31%	4.62%
Turlock Irrigation District	2.76%	3.19%	3.49%	4.88%
Modesto Irrigation District	2.78%	3.25%	3.60%	5.12%
Riverside Utilities Dept.	2.53%	3.23%	3.60%	5.14%
Pasadena Water & Power Dept.	2.97%	3.55%	3.90%	5.26%
San Diego Gas & Electric Co.	3.42%	3.93%	4.26%	5.54%
Southern California Edison Co.	2.91%	3.68%	4.03%	5.71%
Burbank Public Service Dept.	3.21%	3.87%	4.28%	5.80%
Los Angeles Dept. of Water & Power	3.77%	4.34%	4.69%	6.14%
Anaheim Public Utilities Dept.	3.83%	4.41%	4.77%	6.26%
Imperial Irrigation District	4.52%	5.56%	6.22%	8.81%

# Increase in Extreme Heat Events (3-hour)

Utility	Percentile Events	1990- 2000	2020- 2039	2040- 2059	2060 2079	2080- 2099	% $\Delta$	$\Delta$
SacMUD	99.9	2	2.6	7.6	6.2	15.7	783%	13.7
	99	21	44.2	57.6	63.1	89.6	430%	68.7
LADWP	99.9	2	2.7	7.4	7.6	17.2	860%	15.2
	99	21	31.6	43.6	47.8	68.9	331%	48.1
SoCal Edison	99.9	2	3.9	10.2	10.3	24.0	1200%	22.0
	99	21	40.0	56.7	59.7	89.0	428%	68.2
SDG&E	99.9	2	5.4	9.3	9.1	20.3	1015%	18.3
	99	21	42.3	52.1	58.3	79.4	381%	58.5
IID	99.9	2	6.6	13.5	14.8	29.3	1463%	27.3
	99	21	43.8	57.1	61.1	90.5	434%	69.6
PG&E	99.9	2	7.2	16.3	16.2	36.4	1818%	34.4
	99	21	48.9	63.0	67.0	98.4	473%	77.6

# Climate Change Impacts on Peak Demand

Utility	2020-40	2041-60	2061-80	2081-2100
Silicon Valley Power	-0.2%	-0.3%	0.9%	0.1%
Vernon Light & Power Dept.	0.9%	0.9%	1.0%	1.0%
Modesto Irrigation District	0.9%	1.6%	2.7%	3.9%
Sacramento Municipal Utility District	1.4%	2.3%	3.6%	3.9%
Turlock Irrigation District	2.0%	2.6%	3.5%	4.6%
Los Angeles Dept. of Water & Power	5.9%	5.9%	6.5%	6.7%
Anaheim Public Utilities Dept.	7.3%	7.3%	8.1%	8.3%
Pasadena Water & Power Dept.	7.6%	7.4%	9.0%	9.5%
Burbank Public Service Dept.	7.7%	7.4%	9.6%	10.2%
San Diego Gas & Electric Co.	8.2%	8.5%	9.4%	10.4%
Imperial Irrigation District	7.1%	8.1%	8.6%	10.5%
Pacific Gas & Electric Co.	7.5%	8.6%	9.5%	11.6%
Glendale Public Service Dept.	12.1%	11.8%	14.1%	14.8%
Riverside Utilities Dept.	15.0%	17.0%	17.8%	18.5%
Southern California Edison Co.	14.0%	15.4%	16.7%	19.3%



# Conclusions

- Climate Change will affect California's utilities differentially.
- Further inland, more southern utilities with larger shares of residential customers will experience larger increases in demand.
- Peak demand is predicted to increase between 0.1% and 19.3%
- Number of extreme heat days is expected to increase drastically.